CHAPTER 13 SCENARIOS FOR HAWAII'S ENERGY FUTURE

13.1 Overview

Chapter 13 reports on the results of a number of scenario runs conducted to examine ways to improve Hawaii's energy future. The scenarios incorporated actions to increase the efficiency of Hawaii's energy system and to reduce the use of fossil fuels consistent with the other objectives of *HES 2000*. Some of the scenarios were originally designed to evaluate ways to reduce Hawaii's greenhouse gas emissions for the *Hawaii Climate Change Action Plan*. The scenarios discussed in this chapter are compared on the basis of reductions in CO_2 emissions from energy used in Hawaii and for domestic air and marine transportation. The CO_2 emission reductions primarily represent fossil-fuel energy savings, a principal objective of *HES 2000*.

The scenarios were run on the ENERGY 2020 model of Hawaii's energy system. ENERGY 2020 is linked to the Regional Economic Models, Inc. (REMI) model of the economies of each of Hawaii's counties. The REMI model was calibrated to conform to the DBEDT Research and Economic Analysis Division's *Population and Economic Projections for the State of Hawaii to 2020 (DBEDT 2020 Series*). Additional information about the ENERGY 2020 model is provided in Appendix C of this report.

The scenarios were compared to a Base Scenario designed, to the extent possible, to replicate the current Hawaii energy system and known plans for additions through the year 2000. The continued use of existing technologies was assumed and their costs were based upon utility Integrated Resource Plans (IRP plans).

There are several important differences in the scenario runs in *HES 2000* when compared with those conducted in late 1998 for the *Hawaii Climate Change Action Plan*. The *HES 2000* runs used updated Base Scenario input, including the following:

- HELCO's amended IRP;
- MECO's preliminary least-cost IRP plan;
- Updated oil price estimates based on the U.S. Energy Information Administration's *Annual Energy Outlook 1999* (EIA 1998a) for long-term prices and the Second Quarter Short-Term Energy Outlook (EIA 1999c) for near-term prices;
- Renewable energy cost and performance projections from the most recent HECO, HELCO, and MECO IRPs; and
- KE renewable energy cost and performance projections based on nominally equivalent HELCO projects.

Any model must incorporate simplifications, but such simplifications do not negate its utility. The trends and patterns forecast by the model can be used to examine a variety of possible futures. By applying policy or scenario alternatives, the estimated effects of options can be compared against the Base Scenario to estimate their effectiveness. The model also yields estimates of economic effects that help in the evaluation of the costs or benefits of alternative measures. Scenarios that offer desirable outcomes warrant more detailed study and analysis by those organizations able to carry out the recommendations.

13.2 Electricity Scenarios

For *HES 2000*, three scenarios were modeled that were designed to increase renewable energy use and reduce future fossil-fuel energy use and greenhouse gas emissions.

The scenarios generally call for more use of wind than the HECO wind penetration analyses indicate may be used on the three HECO companies' systems. However, very large percentages of the capacity of other island systems are provided by wind. In addition, the wind systems used in these scenarios are additive to fossil-fuel generation and offer fuel savings, but do not provide firm capacity. The results of the modeling show the potential value of these installations and indicate that utilities should carefully analyze potential individual projects.

13.2.1 Base Scenario

The Base Scenario is the current planned Hawaii energy system. The generation units used in this scenario included current operating units and those identified for operation through the year 2020 in utility IRP plans (see Chapter 7). It was also assumed that utility DSM plans, described in Chapter 11, would be implemented for 20 years. The energy-demand reduction effects of all Federal appliance standards and the Hawaii Model Energy Code were also included.

Ground transportation efficiency was based upon observed Hawaii ground transportation fuel efficiency rather than federal CAFE standards (see discussion in Chapter 4). Air transportation was assumed to improve in efficiency at an average 0.7% per year, based upon USDOE base case forecasts. Marine fuel use was assumed to grow at a rate similar to population growth.

13.2.2 E2 – 20% Renewable Energy Scenario

The 20% Renewable Energy Scenario, E2, depicted on Table A.42, in Appendix A, was designed to reflect deployment of renewable energy systems totaling about 20% of all new generation added statewide during the 2000–2020 period. The additional renewables are presented in boldface on Table A.42. The renewable energy resources considered were selected from projects known to be under contract or under negotiation as of late 1999 and recommendations of *HES 1995*. Intermittent resources were added to the utility plans and were not assumed to displace fossil-fuel generation, but to reduce the use of fossil fuels.

13.2.3 E-3 – 10% Renewable Energy Scenario

The 10% Renewable Energy Scenario, E3, depicted on Table A.43 was designed to reflect deployment of renewable energy systems totaling about 10% of all new generation added during the 2000–2020 period. The additional renewables are presented in boldface on Table A.42. The renewable energy resources considered were selected from projects known to be under contract or under negotiation as of late 1999 and recommendations of *HES 1995*. Intermittent resources were added to the utility plans and were not assumed to displace fossil fuel generation, but to reduce fossil fuel use.

13.2.4 Results of the Electricity Scenario Runs

Figure 13.1 shows the CO_2 emissions estimated by the ENERGY 2020 model for the period 1990–2020. None of the three scenarios reduced greenhouse gas

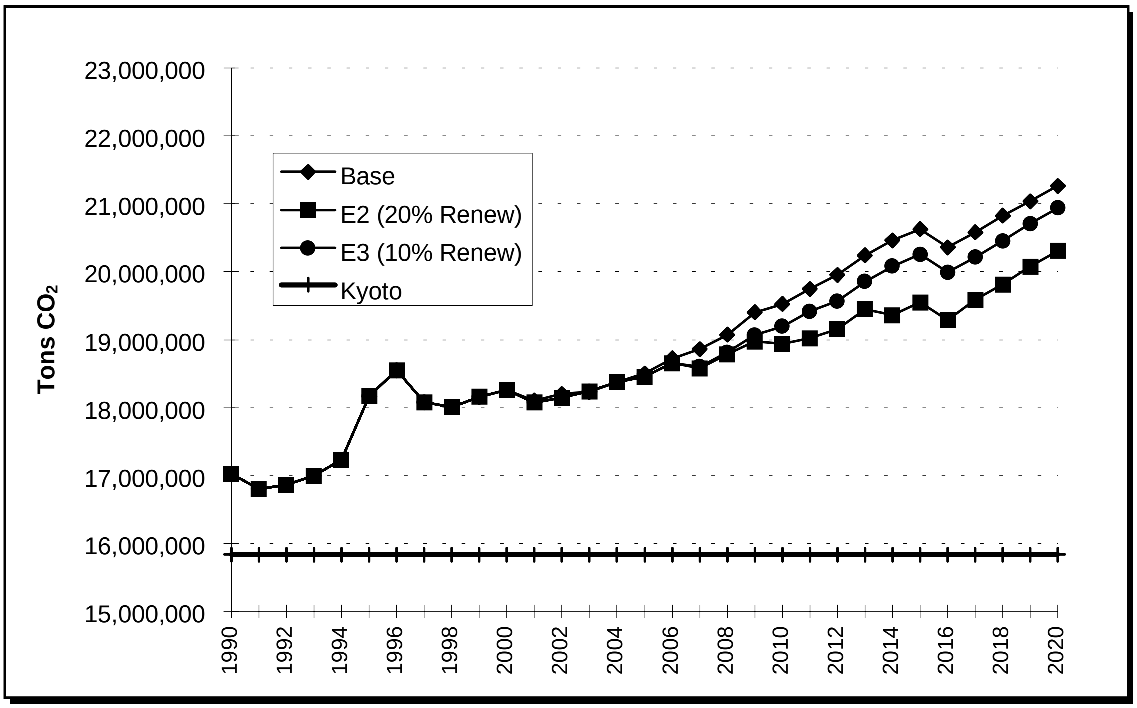

Figure 13.1 Estimated Hawaii CO2 Emissions under Electricity Sector Scenarios, 1990–2020

emissions below the Kyoto target of 7% less than 1990 levels. By 2010, under the Base Scenario, forecast CO_2 emissions were about 3.7 million tons, or 23.3%, above the Kyoto target. The 20% Renewable Scenario offered the greatest reduction of CO_2 but was still estimated to be 1.2 million tons, or 19.6%, above the 2010 target.

It should be kept in mind that these scenarios are presented only for analysis of the effectiveness of various strategies in reducing electricity sector CO_2 emissions. Any decision for actual construction of the projects modeled in the scenarios would require extensive further analysis, including evaluation of updated cost information, the technical feasibility of integrating the particular systems into the electricity system, site availability, and the likelihood of obtaining necessary permits.

13.3 Transportation Energy Scenarios

Transportation energy use was responsible for the largest percentage of Hawaii's CO_2 emissions from domestic energy use. The scenarios were designed to examine potential ways of reducing transportation emissions.

13.3.1 Baseline Scenario

The Baseline Scenario for the transportation scenarios was the same one as used in the electricity sector analysis above. (See Section 13.2.1.)

13.3.2 T2 – 10% Ethanol Blend Gasoline Scenario

Under the T2 Scenario, the use of a blend of 10% ethanol and 90% gasoline in Hawaii was projected to begin in 2000. It was assumed that the ethanol would be produced in Hawaii. Although the model depicted reaching the 10% ethanol level in the first year, in practice, it could take somewhat longer. Nevertheless, it was expected that the full 10% level would be reached before 2010. The T2 Scenario would be possible to implement without major modifications to vehicles or to the gasoline distribution and retailing system.

13.3.3 T3 – 10% Increase in New Vehicle Efficiency Scenario

The T3 Scenario assumed that Hawaii's citizens bought new vehicles 10% more efficient than 1998 purchases beginning in 2001. Such a change in purchase patterns could be initiated through a number of possible means, as discussed in Chapter 4.

13.3.4 T4 – 100% Increase in New Vehicle Efficiency Scenario

Transportation 4 Scenario assumed that Hawaii's citizens bought new vehicles 100% more efficient than 1998 purchases beginning in 2006. Such a change in purchase patterns could be initiated through a number of possible means. The essential factor would be the availability of highly efficient automobiles now in the research and development phase. The Transportation 4 Scenario could be achieved through the use of a combination of highly efficient conventional, hybrid, alternative fuel, and fuel-cell vehicles; and measures to reduce the demand for transportation.

13.3.5 A2 – Aircraft Efficiency Improvements Scenario

The Base Scenario assumed that civilian aircraft efficiency would improve at an average annual rate of 0.7% per year – the nominal estimate of the U.S. Department of Energy. The Department of Energy also estimated that efficiency could improve at a rate of up to 2.5% per year. Scenario A2 modeled such improvements beginning in 1998 and represents a nominal technical potential.

13.3.6 Results of the Transportation Energy Scenario Runs

Figure 13.2 depicts estimated CO_2 emissions for 1990 to 2020 under the transportation scenarios. As with the electricity sector, no single transportation sector scenario reduced CO_2 emissions to the target level.

Scenario T4, the availability and use of increasing numbers of new, highly efficient vehicles beginning in 2006, produced the greatest emissions savings. Yet, overall emissions were 2.23 million tons, or 14.1% greater than the 2010 target. Greater civil aircraft efficiency (Scenario A2) yielded the second greatest savings, but resulted in CO_2 emissions 2.95 million tons, or 18.7%, greater than the Kyoto target in 2010. Scenario T2, 10% ethanol fuel reduced emissions by 3.04 million tons or 19.2% by 2010. Under Scenario T3, 10% increase in fuel efficiency beginning in 2001, emissions were 3.34 million tons, or 21.2% greater than the target.

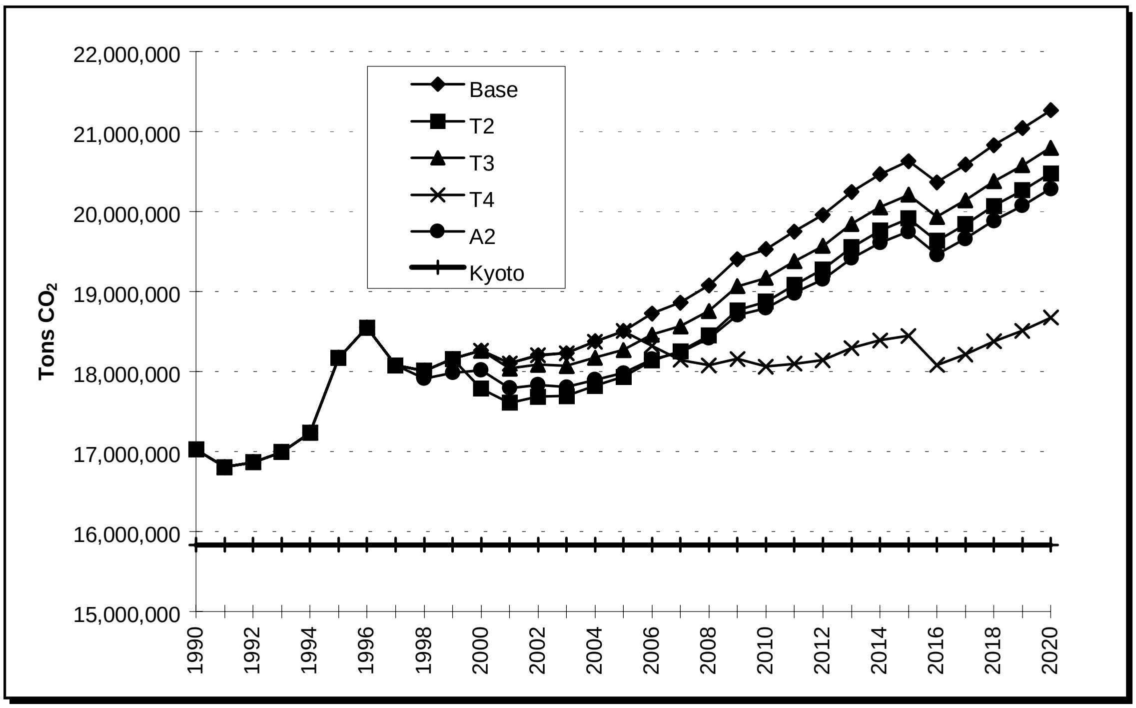

Figure 13.2 Estimated Hawaii CO_2 Emissions under Transportation Sector Scenarios, 1990–2020

13.4 Carbon Tax Scenarios

Carbon taxes, based upon the carbon content of fossil fuels, have been discussed as a way of internalizing the environmental costs of fossil fuel use. They would increase the cost of fuels, thus discouraging their use. In the ENERGY 2020 model, it was assumed that the taxes were a cost to Hawaii's economy. Alternatively, a carbon tax could be used instead to offset other taxes, which would likely reduce the negative consequences of carbon taxes while still tending to reduce fuel use.

It is not clear whether the fuel use reduction would differ depending upon the ultimate payee of the tax and any offsetting deductions from other taxes. These considerations, in addition to the likelihood that the negative economic consequences might be especially harsh for Hawaii, should be explored in detail before such a tax is considered or enacted. Two carbon tax scenarios were examined. They were applied to all fossil fuels and were implemented in 2005. They were as follows:

- **CT1 –** $50 per ton; and
- **CT2 –** $125 per ton.

Figure 13.3 shows the results compared to the Base Scenario, E1.

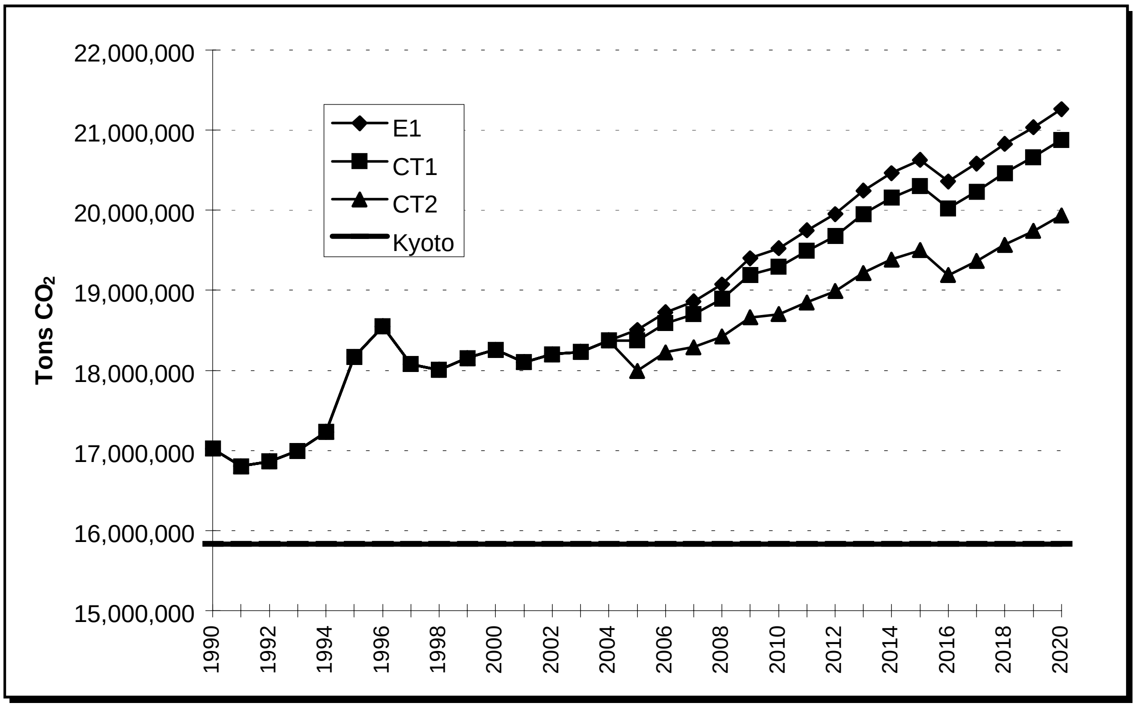

Figure 13.3 Estimated Hawaii CO_2 Emissions under Carbon Tax Scenarios, 1990 – 2020

With CT1, the $50 per ton carbon tax, the model predicted that CO_2 emissions would be 3.46 million tons in 2010, or 21.9% above the Kyoto target. The $125 per ton carbon tax modeled in CT2 still resulted in CO_2 emissions of 2.67 million tons, or 18.1% greater than the target.

Table 13.1, on the following page, shows the additional costs per million Btu and measure of quantity estimated for each level of carbon tax on the fossil fuels used in Hawaii. As expected, the carbon taxes as modeled in Scenarios CT1 ($50 per ton) and CT2 ($125 per ton) reduced energy use and consequent CO_2 emissions.

Table 13.1 Additional Costs of Carbon Taxes by Fuel

	CT1 – $50/Ton C		CT2 – $125/Ton C	
Liquid Fuels	**Cost/10^6 Btu**	**Cost/Gallon**	**Cost/10^6 Btu**	**Cost/Gallon**
Avgas	$ 1.04	$ 0.12	$ 2.60	$ 0.31
Distillate	$ 1.10	$ 0.15	$ 2.75	$ 0.38
Gasoline	$ 1.07	$ 0.13	$ 2.68	$ 0.33
Jet Fuel	$ 1.09	$ 0.15	$ 2.72	$ 0.38
LPG	$ 0.95	$ 0.09	$ 2.36	$ 0.23
Residual	$ 1.19	$ 0.18	$ 2.96	$ 0.44
Solid Fuel	**Cost/10^6 Btu**	**Cost/Ton**	**Cost/10^6 Btu**	**Cost/Ton**
Coal	$ 1.40	$ 0.75	$ 3.50	$ 1.88
Gaseous Fuel	**Cost/10^6 Btu**		**Cost/10^6 Btu**	
SNG	$ 0.80		$ 1.99	

13.5 Combination Scenario Runs

In developing the Combination Scenarios, the individual scenarios discussed above were ranked in order of year 2010 CO_2 savings, as shown on Table 13.2. Table 13.2 shows CO_2 savings compared to the Kyoto target and the percentage by which the emissions under each scenario exceeded the Kyoto target for 2010 and 2020.

Table 13.2 Estimated CO_2 Savings in 2010, 2020, and 2000–2020 by Scenario Compared with Kyoto Target

2010 Rank	Scenario	2010 CO_2 Savings	Above Kyoto	2020 Rank	2020 CO_2 Savings	Above Kyoto
1	GT4 – 100% Vehicle Efficiency Improvement	1,465,366	14.1%	**1**	2,594,113	17.9%
2	CT2 – $125/Ton Carbon Tax	823,656	18.1%	**2**	1,327,828	25.9%
3	A2 – Improved Aircraft Efficiency	735,281	18.7%	**3**	982,555	28.1%
4	GT2 – 10% Ethanol Gasoline	654,434	19.2%	**5**	787,124	29.3%
5	E2 – 20% Renewable Energy	590,867	19.6%	**4**	957,146	28.3%
6	GT3 – 10% Vehicle Efficiency Improvement	358,071	21.1%	**6**	468,378	31.4%
7	E3 – 10% Renewable Energy	330,490	21.2%	**8**	323,259	32.3%
8	CT1 – $50 per Ton Carbon Tax	232,687	21.9%	**7**	382,982	31.9%
9	Base – Utility IRP and DSM	–	23.3%	**9**	–	34.3%

13.5.1 The Combination Scenarios

Three Combination Scenarios were created to group the scenarios that offered the greatest potential CO_2 reductions, to further explore some of the options available to policy-makers, including their effectiveness in reducing greenhouse gas emissions.

C1 – Maximum Reduction Scenario with Maximum Carbon Tax. Scenario C1 combined the electricity scenario with the greatest CO_2 reductions, E2 – 20% Renewable Energy, with four of the transportation scenarios. These included the following:

A2 – Aircraft Efficiency Improvements;

T2 – 10% Ethanol-based Gasoline; and

T4 – 100% Increase in New Vehicle Efficiency.

The maximum carbon tax scenario, CT-2, modeled at $125 per ton of CO_2 was also included.

C2 – Maximum Reduction Scenario without Carbon Tax. This scenario included all of the elements of C1 without the $125 per ton carbon tax (CT-2).

C3 – Hawaii-based Reductions Scenario. C3 was intended to examine the emission reductions under the control of various entities in Hawaii. The scenario also incorporated the E2 – 20% Renewable Energy electricity scenario, and in the transportation sector, T2 – 10% Ethanol-based Gasoline, and T3 – 10% Increase in New Vehicle Efficiency in 2001.

13.5.2 Results of the Combination Scenario Runs

Figure 13.4 and Table 13.3 depict the results of the three Combination Scenarios compared with the Base Scenario and the Kyoto target. The C1 Scenario, Maximum Reduction Scenario with Carbon Tax, reduced CO_2 emissions below the Kyoto target by 2009, and they remained there through 2020. The C2 Scenario, Maximum Reduction Scenario without Carbon Tax, achieved the next greatest estimated CO_2 emissions reduction, reaching a level only 3% above the Kyoto target in 2010, dipping below the target in 2016, and ending 2% above the target in 2020 The reader is reminded that these results depend upon expected advances in transportation technology that may not occur exactly as estimated. The C1 and C2 Scenarios also assume adoption of these technologies by Hawaii’s people, businesses, and institutions. As Figure 13.4 shows, under both Scenarios, emissions growth began to overcome the improvements in efficiency and use of renewable energy about 2016, suggesting that additional measures will be required at that time to achieve further reductions.

C3, the Hawaii-based Reductions Scenario, brought emissions down to within 15% of the Kyoto target by 2010, an 8% improvement over the Base Scenario. By 2020, emissions increased to 19% above the Kyoto Target, a 10% improvement over the Base Scenario.

Under the C3 Scenario, as depicted on Figure 13.4, although the Combination Scenarios reduced CO_2 emissions significantly, energy use grew more rapidly, causing emissions to continue to rise.

13.6 Comparison of Estimated Economic Effects of Scenarios and Recommendations

13.6.1 Estimated Effects on GSP and Personal Income

Figure 13.5 shows the effects of each of the scenarios on Hawaii’s estimated Gross State Product (GSP) and personal income over the period 2000–2020. The negative potential effect of carbon taxes on Hawaii's economy is shown by the results of CT1 and CT2, and Combined Scenario C1. CT2 was estimated to reduce GSP compared to the Base Scenario by $4.6 billion and over the years 2000–2020. This would be 0.55% of total GRP over that period.

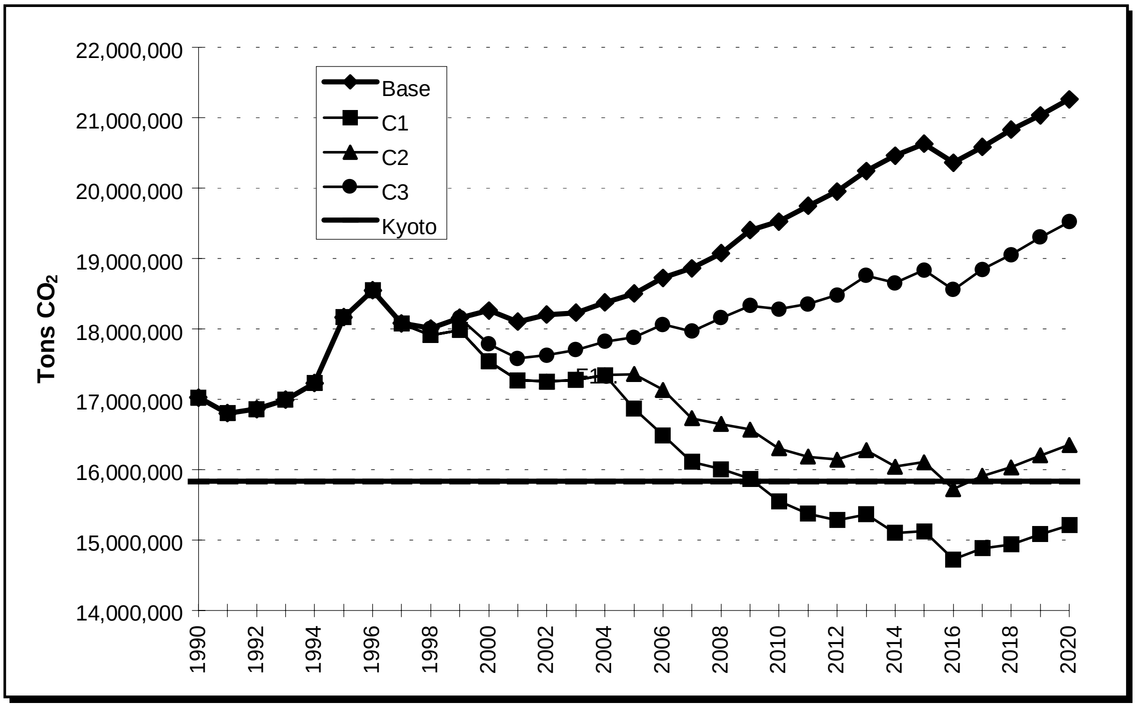

Figure 13.4 Estimated Hawaii CO_2 Emissions under Combination Scenarios, 1990–2020

Table 13.3 Comparison of Combination Scenario CO_2 Savings in Tons of CO_2

Rank	Scenario	2010 CO_2 Savings	% of Kyoto Target	2020 CO_2 Savings	% of Kyoto Target	2000–2020 CO_2 Savings	% of Kyoto Target
1	C1 – Maximum Reduction With Carbon Tax	3,975,836	98%	6,056,272	96%	79,716,821	96%
2	C2 – Maximum Reduction	3,227,055	103%	4,915,761	103%	65,233,163	102%
3	C3 – Hawaii-based Reductions	1,247,184	115%	1,742,424	123%	26,089,419	119%
4	Base – Utility IRP and DSM	–	123%	–	134%	–	129%

13.6.2 Estimated Effects on Employment

As seen in Figure 13.6 and Table 13.4, the effects of the scenarios on employment mirror those of their effect on GSP. The scenarios that included a carbon tax had the greatest detrimental effect on overall employment. Over the years 2000–2020, CT2 reduced employment by 75,123 job-years, or 0.54% (note that the decimal point was misplaced in a similar analysis in the *Hawaii Climate Change Action Plan*. CT1 reduced jobs by about 13,735 job years, or 0.1%. While these numbers are significant in human terms, they would occur over the 21-year period, which would mitigate their effect somewhat. The data do support the argument that a carbon tax should not be considered for Hawaii due to its probable negative economic effects.

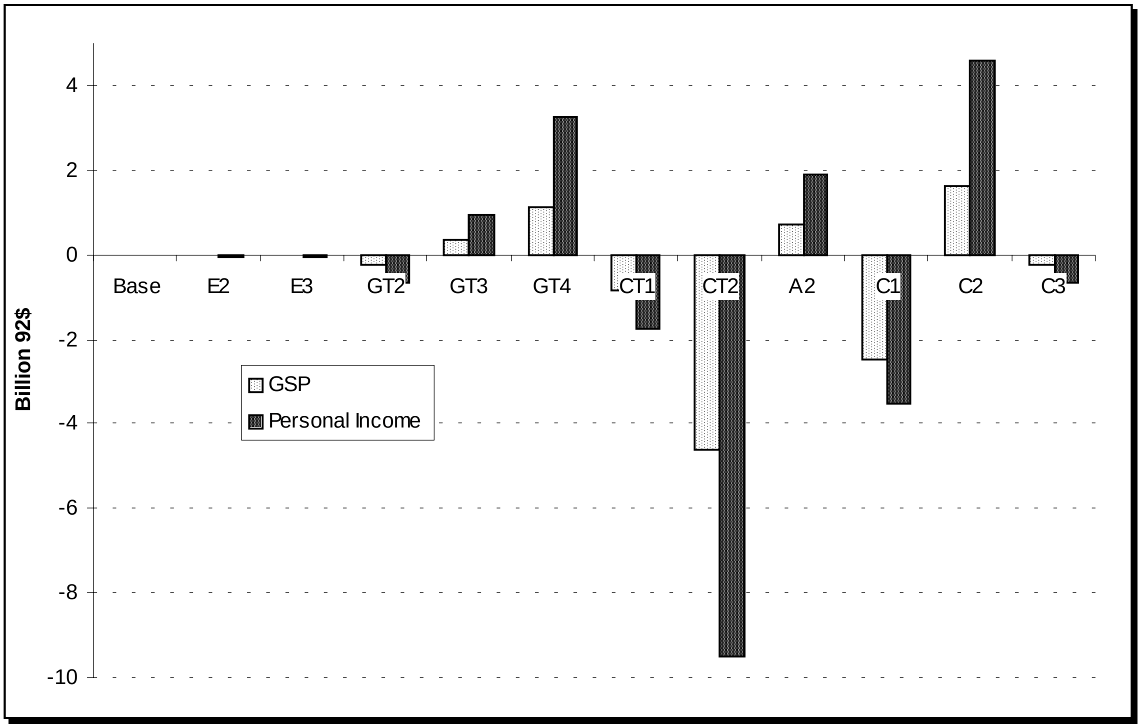

Figure 13.5 Estimated Effects of Scenarios on GSP and Personal Income in Hawaii, 2000–2020

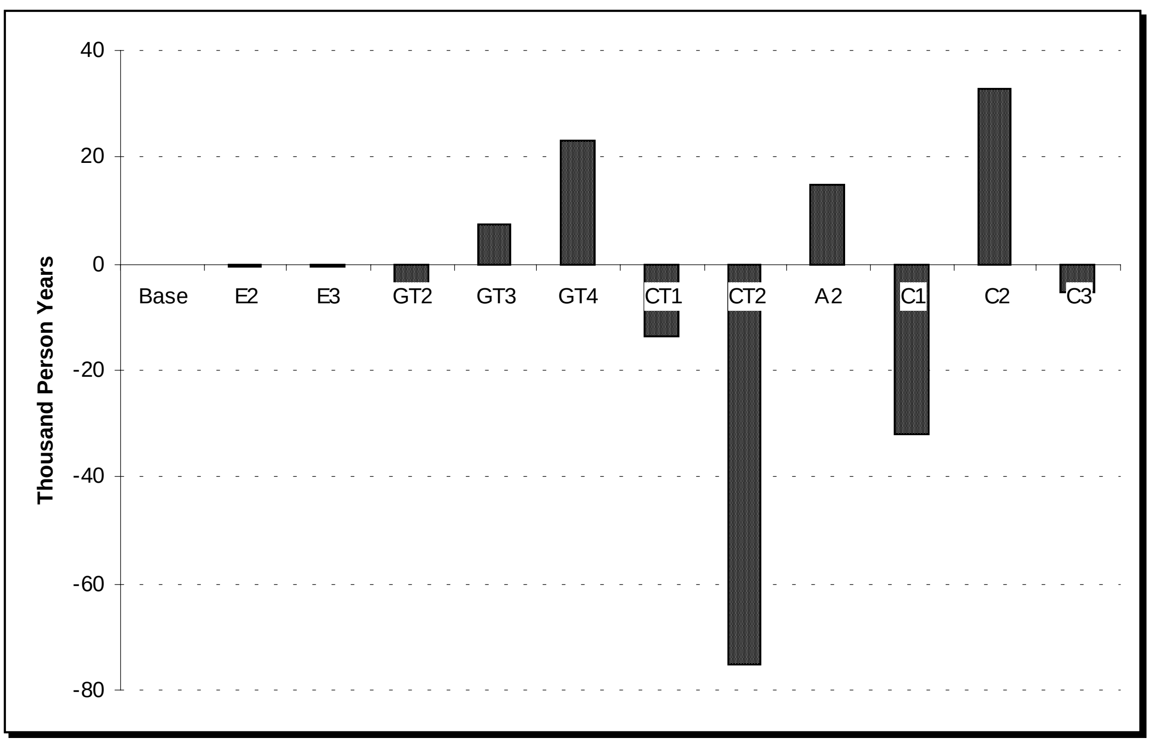

Figure 13.6 Estimated Effects of Scenarios on Employment in Hawaii, 2000–2020

On the positive side, Scenario C2 increased employment by 32,818 job years (0.24%), followed by GT4 at 23,229 job years (0.17%). In all, only four scenarios produced estimated increases in employment.

13.6.3 Summary of Scenario Results

Table 13.4 ranks the scenarios by their estimated CO_2 savings in 2010 and their benefit or cost compared to the Base Scenario GSP, Personal Income, and Employment for the period 2000–2020.

Table 13.4 Scenario Rankings by Estimated CO_2 Savings in 2010, and by GSP, Personal Income, and Employment, 2000–2020

CO_2 Rank	Scenario	2010 CO_2 Savings (Tons)	Effects on Economy 2000–2020: GSP (92$) Rank	GSP (92$) Amount	Personal Income (92$) Rank	Personal Income (92$) Amount	Job Years Rank	Job Years Number
1	C1 – Max Reduction w/ Tax	3,975,836	**10**	(2,494,800,000)	**10**	$(3,536,200,000)	**7**	(2,495)
2	C2 – Max Reduction w/o Tax	3,227,055	**1**	$ 1,612,300,000	**1**	$ 4,583,000,000	**1**	32,818
3	GT4 – 100% Vehicle Efficiency Improvement	1,465,366	**2**	$ 1,136,000,000	**2**	$ 3,267,400,000	**2**	23,229
4	C3 – Hawaii-based Reductions	1,247,184	**8**	$ (248,800,000)	**7**	$ (641,600,000)	**9**	(5,490)
5	CT2 – $125/Ton Carbon Tax	823,656	**11**	(4,602,600,000)	**11**	$(9,486,200,000)	**11**	(75,123)
6	A2 – Improved Aircraft Efficiency	735,281	**3**	$ 711,100,000	**3**	$ 1,913,900,000	**3**	14,789
7	GT2 – 10% Ethanol Gasoline	654,434	**7**	$ (244,900,000)	**8**	$ (643,900,000)	**8**	(5,385)
8	E2 – 20% Renewable Energy	590,867	**5**	$ (18,900,000)	**5**	$ (52,900,000)	**5**	(470)
9	GT3 – 10% Vehicle Efficiency Improvement	358,071	**4**	$ 341,800,000	**4**	$ 940,200,000	**4**	7,196
10	E3 – 10% Renewable Energy	330,490	**6**	$ (27,400,000)	**6**	$ (69,300,000)	**6**	(580)
11	CT1 – $50 per Ton Carbon Tax	232,687	**9**	(817,600,000)	**9**	$(1,749,600,000)	**10**	(13,735)

Only four scenarios (C2, GT4, A2, and GT3) produced positive economic effects over the 2000–2020 period. Together these confirm the economic benefits of reducing the amount of money spent on imported oil. The next four scenarios, which did not include a carbon tax (E2, E3, GT2, and C3), had relatively small negative effects on GSP. Scenarios C2, CT1, and CT2, which contained a carbon tax had significant negative economic effects.

13.6.4 Scenario-Based Recommendations

The model results suggest that the negative economic effects were most significant in the scenarios with carbon taxes. Based upon the estimated effects of carbon taxes as modeled, however, it is recommended that carbon taxes not be part of efforts to reduce CO_2 emissions. It is possible that these could be imposed at the national level, however. This would add to the cost of fossil fuels and give additional impetus to energy efficiency efforts and the deployment of renewable energy.

13.6.4.1 RECOMMENDATION: Consider Implementing Elements of Scenario C3

Suggested Lead Organizations: DBEDT, Electric Utilities, Non-Utility Generators, and Renewable Energy Developers

Since the policies modeled in Scenario C3 could be implemented at the state level, they are recommended for consideration. Scenario C3 included Scenario E2, Maximize Renewable Energy in the electricity sector and in the ground transportation sector; Scenario GT2, 10% Ethanol-based Gasoline; and Scenario GT3, 10% New Vehicle Efficiency Improvement. GT3 might be implemented through measures that could include fee rebates where higher registration costs on inefficient vehicles are used as incentives to purchase more efficient vehicles. Consumer education could also play an important role in Scenario GT3. Additional recommendations may be found in Chapters 4 and 8.

13.6.4.2 RECOMMENDATION: Support Efforts to Increase the Fuel Efficiency of Aircraft and Ground Vehicles

Suggested Lead Organizations: DBEDT, Airlines, Auto Manufacturers, and the Hawaii Congressional Delegation

It was also clear that, due to the fact that most of Hawaii's energy use is in the form of jet fuel and ground transportation fuels Improvements in fleet efficiency would significantly help reduce energy use CO_2 emissions. As the results of Scenario A2, Aircraft Efficiency Improvements suggest, Hawaii should support aircraft research and development efforts at the national level and encourage airlines serving Hawaii to use their most efficient types of aircraft. The results of the ground transportation scenarios, especially GT4, 100% New Vehicle Efficiency Improvement, suggest that Hawaii should encourage efforts by auto manufacturers to develop and deploy alternative fuel vehicles and high-efficiency vehicles, and to seek federal increases in CAFE standards. Hawaii's citizens should also be made aware of the effects of vehicle use on Hawaii's economy as well as on climate change, and they should be encouraged to purchase fuel-efficient vehicles and to operate them efficiently. Additional recommendations were made in Chapters 4 and 5.

13.6.4.3 RECOMMENDATION: Maximize Renewable Energy and Demand-Side Management in the Electricity Sector

Suggested Lead Organizations: DBEDT, Electric Utilities, Non-Utility Generators, and Renewable Energy Developers

Hawaii should continue efforts to maximize the use of renewable energy, and it should conduct research and development and demonstration projects. Hawaii's utility DSM programs should be encouraged and supported with appropriate tax credits. The utilities should evaluate the full range of possible DSM programs in each IRP cycle to ensure that any measure that may become cost-effective in the face of increasing electricity prices is included. Specific recommendations were made in Chapters 8 and 11.